

## Apparatus for Continuous Joining and/or Welding of Material Webs Using Ultrasound

### Description

The invention relates to an apparatus for the continuous bonding and/or welding of material webs using ultrasound, having an ultrasonic horn configured as a rotating roller, an anvil disposed radially opposite the rotating roller, an amplitude transformer set axially on the rotating roller, and an ultrasonic converter with an energy supply attached to the amplitude transformer.

It is known that for the continuous welding and/or bonding of material webs, they are passed through a rotating roller and a fixed or similarly rotating roller and thereby processed. With fixed ultrasonic horns, large material widths can be covered, but a frictional force arises between the ultrasonic horn and the moving material web, negatively affecting the welding result. In addition, the frictional force causes heating of both the material webs and of the ultrasonic horn, thereby changing the pre-set gap.

The above described disadvantage of friction can be prevented with rotating ultrasonic horns, but only narrow-width welds can be performed. From U.S. 2002/030157 a ultrasonic horn is known with a width that is smaller than lambda-half. This also applies to the devices known from U.S. 5,707,483 and U.S. 6,547,903.

The object of the invention is therefore to prepare an apparatus for the continuous bonding and/or welding of material webs, with which wide material webs can be processed.

This object is achieved with an ultrasonic horn configured as a rotating roller whose length is equal to a lambda-half wave of the imposed oscillation or a multiple thereof.

In the inventive apparatus, the ultrasonic horn configured as a rotating roller has a length which equals lambda-half or a multiple of lambda-half of the imposed oscillation. The length of the rotating roller essentially depends, therefore, on the material used and the desired operating frequency. By multiplying the length of the rotating roller to a multiple of lambda-half of the oscillation, extremely wide material webs can be processed without having to use several individual ultrasonic

horns for this purpose. The material webs can also be dried with the inventive apparatus.

In a further development, radial bearings are furnished between the amplitude transformer and the rotating roller. These radial bearings are located particularly in a nodal point of the longitudinal oscillation, so that no or negligibly small oscillation amplitudes affect the bearings.

An amplitude transformer and an ultrasonic converter are preferably furnished on both sides of the rotating roller. Depending on the requisite energy with which the material webs are to be welded or bonded to each other, either one converter or two converters can be furnished, with the amplitude transformers located so that they can be changed, specifically bolted in. They can be of the same material as the rotating roller.

In one embodiment, the two amplitude transformers and the roller are combined in a single component. Greater strength is achieved thereby, and there is no danger of the amplitude transformers becoming detached from the roller.

The anvil is preferably a rotating counter-roller. Two counter-rotating rollers offer the advantage that friction is limited to a minimum and that the material webs are handled very gently without the processing leading to format changes.

In one variation, the counter-roller is configured as an active roller and possesses two amplitude transformers and at least one converter. Each roller has its own converter.

The outer surface of either the rotating roller or the counter roller can be smooth or patterned. With a patterned roller, a texture can be embossed on the material webs, which results in an even tighter bond. The texture can be a nubby texture, a waffle texture, linear texture or a fantasy pattern.

In another embodiment, the anvil is fixed and configured in particular as a knife, blade, or similar. The knife, blade or similar extends in a tangential direction, so that the welding or bonding of the material webs to each other takes place in linear fashion.

The gap width of the rotating roller and the anvil is adjustable in a known way. The setting can be regulated, so that the gap width is kept constant. This

is of advantage, particularly with temperature changes, since the temperature changes do not then manifest themselves in a change in the gap width.

In a further development, the pressure exerted on the material web by the rotating roller can be adjusted. In particular, a pressure regulator can be furnished, so that consistent pressure is always imposed on the material webs.

In a preferred embodiment, the rotating roller is formed by a hollow shaft with a trunnion at each end. A ultrasonic horn configured in this way is first of all light, secondly it possesses outstanding oscillation properties, since the antinode of the transverse oscillation at a length of lambda-half lies in the middle of the hollow shaft.

The rotating roller can advantageously be cooled or heated. Heat can thereby be drawn off or introduced selectively, keeping welding conditions constant.

In a preferred embodiment, at least two rotating rollers lie against the anvil, arranged in tandem, where in particular the two rollers in tandem are offset to one another in the axial direction by an amount ( $\Delta l$ ). This provides a simple way of being able to increase the energy input and improve the distribution of energy. The amount is a lambda-quarter wave of the imposed oscillation ( $\Delta l = \lambda/4$ ).

In accordance with the invention, the diameter (D) of the rotating roller is partially waisted, where in particular the depth of the waist (E) equals one part of a lambda-half wave of the imposed oscillation ( $E = |x| \cdot \lambda/2$ ). In its oscillating state, the rotating roller temporarily assumes the form of a cylinder, whereby better pressure distribution is achieved.

The rotating roller is advantageously made thicker in diameter such that contact pressure is evenly distributed along its length. This measure similarly contributes to an equalization of pressure distribution along the entire length of the roller, since the deformation of the roller by the contact pressure is compensated. This is specifically achieved by incorporating a bulge in the rotating roller. The change in diameter of the rotating roller corresponds exactly to the bending line.

A further measure to equalize the distribution of pressure is that the axis of the rotating roller and that of the counter-roller anvil are skewed to each other.

Additional advantages, features and details of the invention can be found in the following description, in which particularly preferred embodiments are described in detail with reference to the drawing. The features depicted in the drawing and mentioned in the claims and the description can be essential to the invention individually or in any combination.

Figure 1 shows a perspective view of a preferred embodiment of the invention with an anvil configured as a counter-roller;

Figure 2 shows a section II-II in accordance with Figure 1;

Figure 3 shows a longitudinal section through the rotating roller;

Figure 4 shows a side view of the ultrasonic horn with amplitude transformers;

Figure 5 shows a diagram showing the oscillations running in the transverse and longitudinal direction;

Figure 6 shows a perspective view of an embodiment with two rotating rollers;

Figure 7 shows a side view toward the arrow VII in accordance with Figure 6;

Figure 8 shows an embodiment with two rotating rollers offset to each other;

Figure 9 shows a side view of an embodiment with a rotating roller having waists;

Figure 10 shows a plan view onto an embodiment in which the axes of the rotating roller and the counter-roller are skewed relative to each other;

Figure 11 shows a side view toward the arrow XI in accordance with Figure 10; and

Figure 12 shows an enlarged reproduction of the section XII in accordance with Figure 11.

In Figure 1, two rotating components can be seen, identified in general with 10 and 12, between which two or more material webs 14 and 16 are being fed, wherein the two material webs 14 and 16 are bonded and/or welded together as they

pass through a working gap identified in general with 18. The pass-through direction is indicated by the arrow 20.

The component 10 possesses a central rotating roller 22, to which amplitude transformers 24 are attached on both sides, with radial bearings 26 furnished on said transformers. The amplitude transformers 24 are coupled to ultrasonic converters 28 through which a mechanical vibration can be generated in the longitudinal direction, i.e. in the direction of the double arrow 30. Rotary couplers 32 are furnished on the end faces of the ultrasonic converters 28 through which the ultrasonic converters 28 are provided with energy.

A counter-roller 34, which is similarly carried rotatably on radial bearings 36, is disposed opposite the rotating roller. The surface of the counter-roller 34 has ribs 50 running in the longitudinal direction which impart a texture to the counter-roller which is transferred to the material webs 14 and 16 when they are bonded.

In Figure 2, the arrows 38 and 40 indicate the rotational directions of the rotating roller 22 and the counter-roller 34. The rotary coupler 32 can also be seen, through which the ultrasonic converter 28 is supplied with energy.

Figure 3 shows a longitudinal section through the rotating roller 22, which in the embodiment shown is formed by a hollow shaft 42 which is closed by trunnions 44. The amplitude transformers 24 (not shown in Figure 3) are attached to these trunnions 44.

Figure 4 shows a side view of the rotating roller 22 with the laterally attached amplitude transformers 24 and the radial bearing 26. In the embodiment shown, the length  $l$  of the rotating roller 22 equals lambda-half ( $\lambda/2$ ) of the oscillation imposed by the amplitude transformers 24. The two radial bearings 26 are spaced lambda-quarter ( $\lambda/4$ ) from the end faces of the rotating roller 22 and the two amplitude transformers 24 extend by lambda-quarter ( $\lambda/4$ ) beyond the radial bearings 26.

The diagram shown in Figure 5 shows the longitudinal oscillation, reference numeral 46, which is generated by the amplitude transformers 24. The transverse oscillation runs offset to it by lambda-quarter ( $\lambda/4$ ), causing an oscillation

of the rotating roller in the radial direction by which the welding process is carried out.

In the embodiment in Figure 4, the length  $l$  of the rotating roller is lambda-half ( $\lambda/2$ ), although the length can also be a multiple thereof, as indicated in Figure 3. In this way it is possible to bond material webs 14 and 16 whose width is greater than lambda-half.

In Figures 6 through 8, two rotating rollers 22 are arranged around the counter-roller 34, with the rotating rollers 22 disposed behind one another and offset by an angle of  $50^\circ$  to  $60^\circ$  and additionally offset to each other in the axial direction by an amount of  $\Delta l = \lambda/4$ , which is shown clearly in Figure 8. The two rotating rollers 22 can be configured identically and are driven by the same frequency generator or oscillate in the same direction.

Figure 9 shows an embodiment in which the rotating roller 22 has a waist E whereby the diameter D is selectively reduced over the length of the roller 22. The transverse oscillation 48 of the roller 22 is also shown diagrammatically in Figure 9. It can be seen that the waist E is always deepest where an oscillation antinode is located. The amount of the waist E is thus the product of a constant and lambda-half ( $E = |x| \cdot \lambda/2$ ). When the rotating roller 22 is set oscillating, it temporarily assumes the form of a cylinder.

Figures 10 through 12 show a variation in which the one of the two rotating rollers 22 is set at an angle, so that its longitudinal axis 52 is skewed to the longitudinal axis 54 of the counter-roller 34. The skew angle is identified in Figure 10 by  $\alpha$ . The section identified in Figure 11 by XII is shown enlarged in Figure 12, and it is clearly recognizable that the contact line of the two rollers does not run parallel to their axes but obliquely. The contact pressure can thereby be equalized.